CLAIMS

Claim 1 (original): Method for estimating the seismic illumination fold $\mathrm{I}(\bar{x}, \bar{p})$ in the migrated 3D domain at least one image point $\bar{x}$, for at least one dip of vector $\bar{p}$, wherein the illumination fold $\mathrm{I}(\bar{x}, \bar{p}; \bar{s}, \bar{r})$ for each (source $\bar{s}$, receiver $\bar{r}$) pair in the seismic survey is estimated, by applying the following steps:

– determination of the reflection travel time $t_r(\bar{x}_r(\bar{p}); \bar{s}, \bar{r})$ from the source $\bar{s}$ to the specular reflection point $\bar{x}_r$ on the plane reflector passing through the image point $\bar{x}$ and perpendicular to the dip vector $\bar{p}$ and then returning to the reflector $\bar{r}$;

starting from the diffraction travel time $t_d(\bar{x}; \bar{s}, \bar{r})$ from the source $\bar{s}$ to the said image point $\bar{x}$ and then returning to the reflector $\bar{r}$;

– incrementing the said illumination fold $\mathrm{I}(\bar{x}, \bar{p}; \bar{s}, \bar{r})$ related to the said (source $\bar{s}$, receiver $\bar{r}$) pair as a function of the difference between the diffraction travel time $t_d(\bar{x}; \bar{s}, \bar{r})$ and the reflection travel time $t_r(\bar{x}_r(\bar{p}); \bar{s}, \bar{r})$.

Claim 2 (original): Method according to claim 1, comprising the step of summating each of the said illumination folds $\mathrm{I}(\bar{x}, \bar{p}; \bar{s}, \bar{r})$ related to a (source $\bar{s}$, receiver $\bar{r}$) pair so as to determine the total illumination fold $\mathrm{I}(\bar{x}, \bar{p}) = \sum_{\bar{s}, \bar{p}} \mathrm{I}(\bar{x}, \bar{p}; \bar{s}, \bar{r})$.

Claim 3 (previously amended): Method according to claim 1, wherein, during the incrementing step, the illumination fold $\mathrm{I}(\bar{x}, \bar{p}, \bar{s}, \bar{r})$ is incremented using an increment function $\mathrm{i}(t_d, t_r; \bar{s}, \bar{r})$ according to $\mathrm{I}(\bar{x}, \bar{p}) = \mathrm{I}(\bar{x}, \bar{p}) + \mathrm{i}(t_d t_r; \bar{s}, \bar{r})$, the said increment function taking account of the difference between the diffraction travel time $t_d(\bar{x}; \bar{s}, \bar{r})$ and the reflection travel time $t_r(\bar{x}_r(\bar{p}); \bar{s}, \bar{r})$.

Claim 4 (original): Method according to claim 3, wherein the increment function i is a function of the seismic wavelet s(t).

Claim 5 (original): Method according to claim 4, wherein the increment function i is expressed as a function of the derivative of the seismic wavelet s(t) according to:

$\mathrm{i}\,(t_d, t_r; \bar{s}, \bar{r}) = \mathrm{s}(\,t_d\,(\bar{x}; \bar{s}, \bar{r}) - t_r\,(\bar{x}_r\,(\bar{p}); \bar{s}, \bar{r})$.

Claim 6 (original): Method according to claim 4, wherein the increment function i is expressed as a function of the derivative $\bar{s}$ (t) of the seismic wavelet s(t) with respect to time according to:

$\mathrm{i}\,(t_d, t_r; \bar{s}, \bar{r}) = (\,t_d\,(\bar{x}; \bar{s}, \bar{r}) - t_r\,(\bar{x}_r\,(\bar{p}); \bar{s}, \bar{r})$.

Claim 7 (original): Method according to any one of claims 3 to 6, in which an a priori correction $\mathrm{w}\,(\bar{x}, \bar{s}, \bar{r})$ of the illumination fold is taken into account by migration, comprising the step of incrementing the illumination fold $\mathrm{I}(\bar{x}, \bar{p}; \bar{s}, \bar{r})$ related to a (source $\bar{s}$, receiver $\bar{r}$) pair by $\mathrm{i}\,(t_d t_r; \bar{s}, \bar{r})\,.\,w(\bar{x}; \bar{s}, \bar{r})$.

Claim 8 (previously presented): Method according to claim 1, wherein the determination step includes the second order Taylor series development of the diffraction travel time $t_d\,(\bar{x}; \bar{s}, \bar{r})$ around the image point $\bar{x}$:

$$t_d\,(\bar{x}; \bar{s}, \bar{r}) = t_d\,(\bar{x}; \bar{s}, \bar{r}) + (\overline{\nabla}_x t_d\,(\bar{x}; \bar{s}, \bar{r}))^{\mathrm{T}} \cdot (\bar{x}_r - \bar{x}) + 1/2(\bar{x}_r - \bar{x})^{\mathrm{T}} \cdot \Delta_{x,x} t_d\,(\bar{x}; \bar{s}, \bar{r}) \cdot (\bar{x}_r - \bar{x})\,.$$

Claim 9 (original): Method according to claim 8, wherein the specular reflection point $\bar{x}_r(\bar{p})$ is determined along the length of the said reflector such that the diffraction travel time at the said specular reflection point $\bar{x}_r(\bar{p})$ is stationary, according to the equation:

$$\bar{p}^{\mathrm{T}} \Lambda(\overline{\nabla}_x t_d\,(\bar{x}; \bar{s}, \bar{r}) + (\Delta_{x,x} t_d\,(\bar{x}; \bar{s}, \bar{r}) \cdot (\bar{x}_r(\bar{p}) - \bar{x})) = \bar{0}\,.$$

Claim 10 (previously presented): Method according to claim 8, wherein the specular reflection point $\overline{x}_r$ and the reflection travel time $t_r(\overline{x}_r(\overline{p});\overline{s},\overline{r})$ are determined according to the following expressions:

$$\overline{x}_r(\overline{p})=\overline{x}-\mathrm{M.F}^{-1}\,\overline{b}$$

$$t_r(\overline{x}_r(\overline{p});\overline{s},\overline{r})=t_d(\overline{x};\overline{s},\overline{r})-1/2\cdot\overline{b}^r\cdot\mathrm{F}^{-1}\cdot\overline{b}$$

where:

– M is a (3 x 2) matrix described by two vectors extending along the length of the reflector, and therefore perpendicular to the dip vector $\overline{p}$;

– $\overline{b}$ is a (2 x 1) vector of first order derivatives of the diffraction travel time along the reflection plane: $\overline{b}=\mathrm{M}^{\mathrm{T}}\cdot(\overline{\nabla}_x t_d)$;

– F is a (2 x 2) matrix of second order derivatives of the diffraction travel time along the reflection plane: $\mathrm{F}=\mathrm{M}^{\mathrm{T}}\cdot(\Delta_{x,x}t_d)\cdot\mathrm{M}$.

Claim 11 (previously presented): Method according to claim 10, wherein the determination step uses isochronic migration maps $t_d(\overline{x};\overline{s},\overline{r})$ specified for each (source $\overline{s}$, receiver $\overline{r}$) pair involved in the migration at each image point $\overline{x}$ in the migrated 3D domain.

Claim 12 (original): Method according to any one of the preceding claims, wherein the seismic illumination fold $\mathrm{I}(\overline{x},\overline{p})$ in the migrated 3D domain is estimated during the Kirchoff summation migration of seismic data recorded during the 3D seismic prospecting.

Claim 13 (previously presented): Method for correction of seismic data amplitudes recorded during 3D seismic prospecting in order to compensate for the effect of non-uniform illumination of sub soil reflectors, comprising the steps of:

– estimating the illumination fold $\mathrm{I}(\overline{x},\overline{p})$ using the method according to claim 1,

– using the inverse $\mathrm{I}^{-1}(\overline{x},\overline{p})$ of the said ratio as a weighting factor to be applied to each of the said seismic data amplitudes.

Claim 14 (previously presented): Method for selection of an acquisition geometry among a plurality of acquisition geometries as a function of the target of 3D seismic prospecting, comprising the steps of:

– determining the illumination fold $\mathrm{I}(\bar{x},\bar{p})$ by the method according to claim 1, for each of the acquisition geometries considered,

– selecting the acquisition geometry providing the optimum illumination fold as a function of the target.

Claim 15 (previously presented): Method according to claim 2, wherein, during the incrementing step, the illumination fold $\mathrm{I}(\bar{x},\bar{p};\bar{s},\bar{r})$ is incremented using an increment function i $(t_d,t_r;\bar{s},\bar{r})$ according to $\mathrm{I}(\bar{x},\bar{p}) = \mathrm{I}(\bar{x},\bar{p}) + \mathrm{i}\ (t_d,t_r;\bar{s},\bar{r})$, the said increment function taking account of the difference between the diffraction travel time $t_d(\bar{x};\bar{s},\bar{r})$ and the reflection travel time $t_r(\bar{x}_r(\bar{p});\bar{s},\bar{r})$.

Claim 16 (previously presented): Method according to claim 15, in which an a priori correction w $(\bar{x},\bar{s},\bar{r})$ of the illumination fold is taken into account by migration, comprising the step of incrementing the illumination fold $\mathrm{I}(\bar{x},\bar{p};\bar{s},\bar{r})$ related to a (source $\bar{s}$, receiver $\bar{r}$) pair by i $(t_d,t_r;\bar{s},\bar{r})$. $w(\bar{x};\bar{s},\bar{r})$.

Claim 17 (previously presented): Method according to claim 16, wherein the determination step includes the second order Taylor series development of the diffraction travel time (x; s, r) around the image point x:

$$t_d(\bar{x};\bar{s},\bar{r})=t_d(\bar{x};\bar{s},\bar{r})+(\overline{\nabla}_x t_d(\bar{x};\bar{s},\bar{r}))^{\mathrm{T}}\cdot(\bar{x}_r-\bar{x})+1/2(\bar{x}_r-\bar{x})^{\mathrm{T}}\cdot\Delta_{x,x}t_d(\bar{x};\bar{s},\bar{r})\cdot(\bar{x}_r-\bar{x}).$$

Claim 18 (previously presented): Method according to claim 17, wherein the specular reflection point $\bar{x}_r(\bar{p})$ is determined along the length of the said reflector such that the diffraction travel time at the said specular reflection point $\bar{x}_r(\bar{p})$ is stationary, according to the equation:

$$\bar{p}^{\mathrm{T}}\Lambda(\overline{\nabla}_x t_d(\bar{x};\bar{s},\bar{r})+(\Delta_{x,x}t_d(\bar{x};\bar{s},\bar{r})\cdot(\bar{x}_r(\bar{p})-\bar{x}))=\bar{0}.$$

Claim 19 (previously presented): Method according to claim 18, wherein the specular reflection point $\overline{x}_r$ and the reflection travel time $t_r(\overline{x}_r(\overline{p});\overline{s},\overline{r})$ are determined according to the following expressions:

$$\overline{x}_r(\overline{p}) - \overline{x} - M . F^{-1} . \overline{b}$$

$$t_r(\overline{x}_r(\overline{p});\overline{s},\overline{r}) = t_d(\overline{x};\overline{s},\overline{r}) - 1/2 \cdot \overline{b}^r \cdot F^{-1} \cdot \overline{b}$$

where:

- M is a (3 x 2) matrix described by two vectors extending along the length of the reflector, and therefore perpendicular to the dip vector $\overline{p}$;

- $\overline{b}$ is a (2 x 1) vector of first order derivatives of the diffraction travel time along the reflection plane: $\overline{b}$ = $M^T \cdot (\overline{b} = M^T \cdot (\overline{\nabla}_x t_d)$;

- F is a (2 x 2) matrix of second order derivatives of the diffraction travel time along the reflection plane: $F = M^T \cdot (\Delta_{x,x} t_d) \cdot M$.

Claim 20 (previously presented): Method according to claim 19, wherein the determination step uses isochronic migration maps $t_d(\overline{x};\overline{s},\overline{r})$ specified for each (source $\overline{s}$, receiver $\overline{r}$) pair involved in the migration at each image point $\overline{x}$ in the migrated 3D domain.

Claim 21 (previously presented): Method according to claim 20, wherein the seismic illumination fold $I(\overline{x},\overline{p})$ in the migrated 3D domain is estimated during the Kirchoff summation migration of seismic data recorded during the 3D seismic prospecting.